

University of Kansas Sustainable Automotive Engineering

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Presenter Background

- BSME: University of Florida
- MSME, MSAE, PhDME: University of Michigan
- Post-Doc: University of Michigan
- Assistant Professor in KU Department of Mechanical Engineering since 2008
- Emphasis: Internal Combustion Engines, Hybridization, Energy and the Environment



Outline

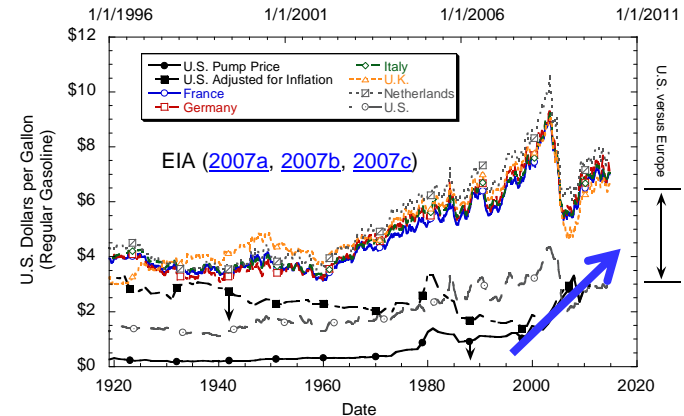
- Shift in Priorities
- Vision of Future: Choice = Application
- Sustainable Automotive Engineering
- Large Scale Practicality
- Small Scale Innovation
- Conclusion



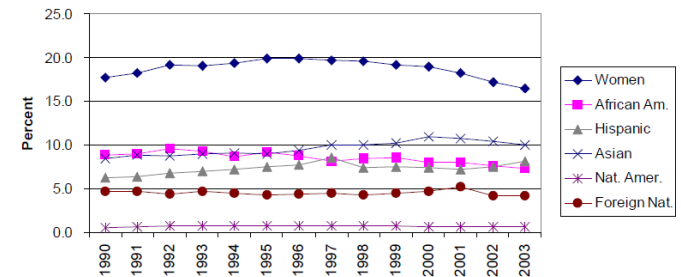
Shift in Priorities

- Mindset of consumer shifted with automotive industry caught off guard
- Vehicles were touted for power over fuel economy
- Adaptive automotive priorities must occur within a university curriculum
- Moreover, traditional view of “gearhead” students in automotive engineering *must* be replaced with a reflection of the diversity of modern society

Rise in Gasoline Prices



Women and Minorities as a Proportion of First-Year Undergraduate Engineering Enrollments, 1990 to 2003



First-year enrollment in engineering dropped 3% to 103,834 in 2003. Even more disturbing is the continuing decline in recent years of women and African Americans as a proportion of first year enrollments.



Vision of Future: Choice = Application

- A singular focus is erroneous...



Semi-trucks running on biodiesel
created from algae



EV in-town/city
delivery trucks



CNG public transit



Parallel hybrid soybean oil
biodiesel garbage truck



KC commuter PHEV with
cellulosic E-85 generator



Muscle car gasoline
parallel hybrid



Diesel SUV



Green gasoline
pick-up truck



H₂ Fuel Cell commuter vehicle



Peanut oil biodiesel tractor



LPG Motorcycle



People who don't care



Picture references available upon request

Sustainable Automotive Engineering

- Informed choice depends on system understanding
 - Classic definition: “meeting the needs of the present without compromising the ability of future generations to meet their own needs” (Bruntland Commission, 1992)
- KU EcoHawks: the application of engineering principles to solving a real-world problem by focusing upon the connection between the *environment, energy, economy, education* and *ethics*
- Conceptual picture on how to make correct decisions that are long lasting
- Provide adaptive framework that allows diverse group of students to choose unique focus (small or large scale)



Environmental Sustainability

- Alternative, renewable and biofuels investigation
- Vehicle recycling to eliminate embodied emissions
- Enhanced powertrains making inefficient vehicles efficient
- Old barn rejuvenated into vehicle manufacturing facility



Conversion of 1974 VW Super Beetle into Plug-in Hybrid Electric Vehicle that can charge using 100% used cooking oil biodiesel generator or solar energy filling station



Energy Sustainability

- Automobiles can be considered a sink or they can be a source
- Investigating grid connection to vehicle (system approach)
- Use vehicle as renewable energy storage medium
- Offset stress on electrical grid
- Local availability of energy (biofuels/sun/wind) versus foreign sources
- National security tied to smart use of energy

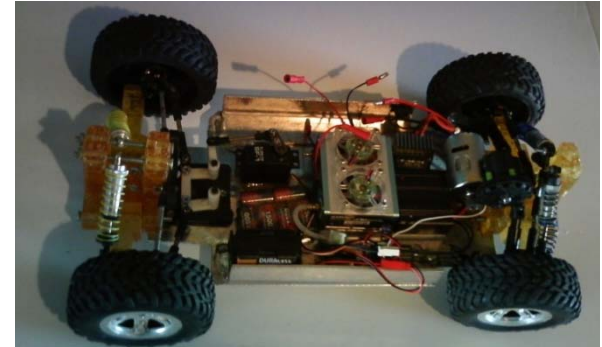


Student built solar energy charging station can refill Beetle in half a sunny day



Economic Sustainability

- Innovate, but keep costs moderate
- Small scale allows novelty (e.g. 1/10th scale parallel-hybrid semi-truck in 2010-11)
- Recycling common large scale vehicles allows use of aftermarket parts
- In-kind donations reduce costs
- Actively writing grants and securing independent donations



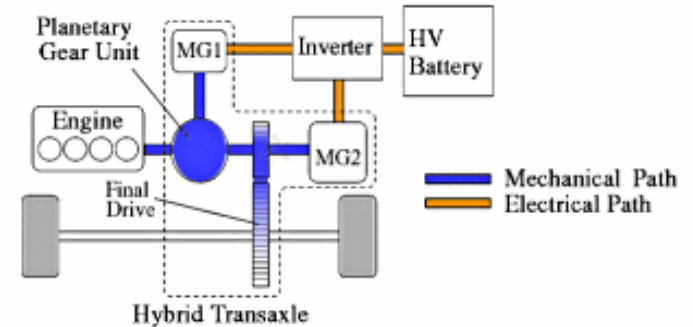
(Above) KU Remote Control fuel cell vehicle \approx \$1,500

(Below) SAHMO fuel cell concept that won Shell Eco Marathon \approx \$170,000



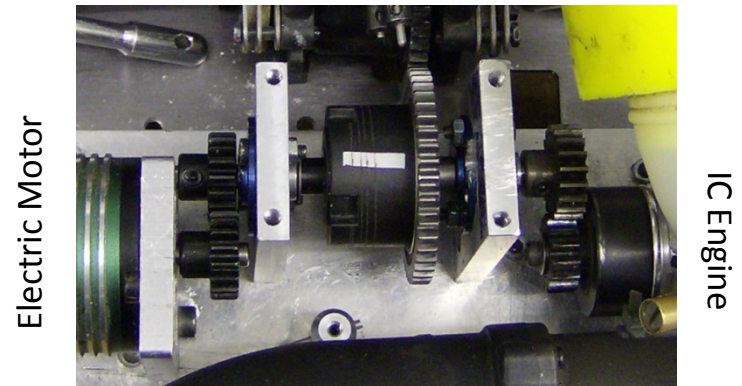
Educational Sustainability

- Need to expose students to new technologies
- Foster interdisciplinary relationships
 - Aerospace, Electrical, Chemical, Industrial Design, Business, etc...
- Allow students to fail with reduced ramifications (failure is an essential part of success!)
- Success and revisit is easier (2nd version of parallel hybrid drive train indicated)
- Writing and presenting efforts large part of grade



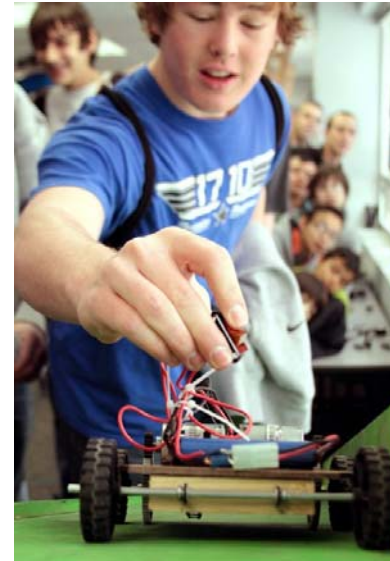
(Above) Toyota Prius parallel hybrid drivetrain

(Below) EcoHawks parallel hybrid drivetrain in RC car



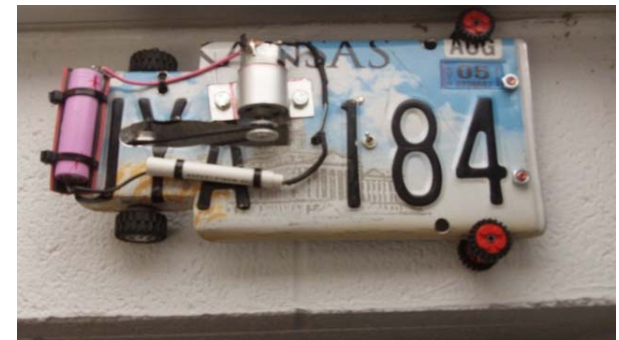
Incorporating K-16 Education

- Current state of US illustrates STEM shortage
- Getting word out through conferences and publications
- Running battery powered vehicle competition for students at KU Engineering Exposition
- KU Weekend of Engineering for high school girls (3/6/11): “The girls always love the EcoHawk visit. They consistently ask the most questions and are the most engaged during your presentation.”



(Left) Student competing in 2011 KU Engineering Exposition competition

(Below) Winning car used recyclable resources and used laptop battery



Ethical Sustainability

- Just building the fastest, most efficient or greenest car will not be the right result
- Ethics must play into the decision and how will the public view the results?

FUEL SOURCES		GREENHOUSE GAS EMISSIONS* Kilograms of carbon dioxide created per mega joule of energy produced	USE OF RESOURCES DURING GROWING, HARVESTING AND REFINING OF FUEL				PERCENT OF EXISTING U.S. CROP LAND NEEDED TO PRODUCE ENOUGH FUEL TO MEET HALF OF U.S. DEMAND	PROS AND CONS
CROP	USED TO PRODUCE		WATER	FERTILIZER	PESTICIDE	ENERGY		
Corn	Ethanol	81-85	high	high	high	high	157%-262%	Technology ready and relatively cheap, reduces food supply
Sugar cane	Ethanol	4-12	high	high	med	med	46-57	Technology ready, limited as to where will grow
Switch grass	Ethanol	-24	med-low	low	low	low	60-108	Won't compete with food crops, technology not ready
Wood residue	Ethanol, biodiesel	N/A	med	low	low	low	150-250	Uses timber waste and other debris, technology not fully ready
Soybeans	Biodiesel	49	high	low-med	med	med-low	180-240	Technology ready, reduces food supply
Rapeseed, canola	Biodiesel	37	high	med	med	med-low	30	Technology ready, reduces food supply
Algae	Biodiesel	-183	med	low	low	high	1-2	Potential for huge production levels, technology not ready

* Emissions produced during the growing, harvesting, refining and burning of fuel. Gasoline is 94, diesel is 83.

Source: Martha Groom, University of Washington; Elizabeth Gray, The Nature Conservancy; Patricia Townsend, University of Washington; as published in Conservation Biology

SEATTLE P-I



Vision of the KU EcoHawks

A Sustainable Approach to Automobiles and Energy Infrastructure

Large Scale Practicality
&
Small Scale Innovation

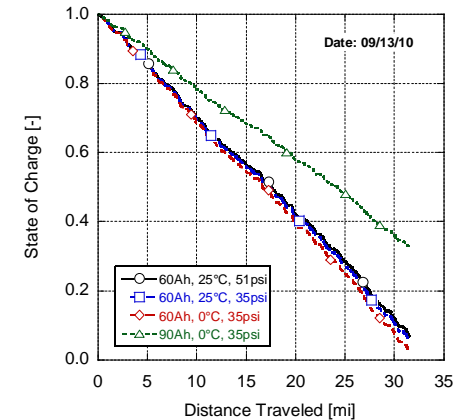


Large Scale Practicality

- Currently renovating 1997 GMC Jimmy
- Making it a Battery Electric Vehicle (BEV) for KU Libraries in daily delivery of material
- Repeatable driving cycle and charging location
- Increasing level of technology of program (AC motor and lithium batteries)
- Choice = application

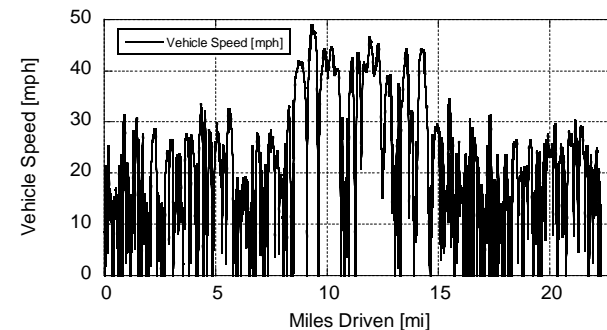


(Top Left) 1997 GMC Jimmy minus Internal Combustion engine



(Top Right) BEV simulation of recycled vehicle with LiFeYPO_4 batteries

(Below) Driving cycle data collection on KU Libraries vehicle



Small Scale Innovation

- Received EPA P³ grant to build small scale intelligent/smart grid
- Presenting on National Mall in April
- Interconnection with BEV and PHEV important
- Data collection in Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) manner
- Will publish and present results
- Only model smart grid available in Nation with vehicle connectivity



Mobile scale smart grid including BEV battery pack, solar panel, wind turbine, renewable energy storage, conventional grid analog, battery management system, National Instruments data collection system, etc...

Conclusion

- New, innovative program started at the University of Kansas
- Follows tenets of sustainability to ensure decisions being put in correct focus
- Students having fun, maintaining grades and learning new expertise
- Now, largest senior design class in ME (11 first year, 32 second year, 28 third year)
- Future technologies incorporated now
- Graduate program growing from efforts



Thank You!



Class Schedule

- ME 640 Fall: 1 credit hour devoted to determining focus, writing a proposal and describing what team wants to accomplish
- ME 645 Spring: 2 credit hours devoted to performing the work and writing up results



Abstract

- University of Kansas (KU) students, who refer to themselves as the EcoHawks, apply engineering techniques in order to solve real-world problems by approaching the situation from five vectors of success: education, energy, environment, economics and ethics. Each of these concepts individually addresses specific aspects of sustainability, shaped by the confluence of the ideals of people, planet and prosperity. It is through this multi-leveled application that the students develop the means to face the challenges of a sustainable approach to automobiles and the energy infrastructure. This presentation will discuss how the following efforts include a practical approach to sustainability for current and future national needs in this area.
- To date, the students have recycled a 1974 VW Super Beetle that had been sitting on a car lot for over two years and turned it into a plug-in series hybrid vehicle powered by lead-acid batteries and a diesel generator that runs on 100% biodiesel created from the used cooking oil on campus. In addition, students built a solar energy filling station on campus that allows recharging of the Beetle battery pack in a little over half a sunny day. Current efforts focus on integrating wind energy into the facility while renovating a 1997 GMC Jimmy into a modern Electric Vehicle (AC three-phase motor and LiFePO₄ batteries) for use by KU Libraries on campus. Moreover, students have been able to explore advanced technologies on the small scale adding to the future capabilities of the project. This is evident by the student's unique Remote Control car builds involving fuel cell and parallel hybrid vehicles and their smart grid demonstration project in progress. Finally, the students actively integrate K-12 education in their efforts through Engineering Exposition and work interdisciplinary with other KU peers.

